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LARGE SCALE DEFORMATION OF THE WESTERN U.S. CORDILLERA

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Annual Report

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INTRODUCTION

This annual report summarizes achievements made under NASA grant NAG5-11629. The majority of our effort, during this past funding cycle, was to publish new results from two distinct previously NASA supported projects. We list all publications that have resulted from this research below. In the next section, we outline the research which formed the basis for the publications supported by NAG5-11629.

RESEARCH INVESTIGATIONS

WUSC

Over the past couple of years, with support from NASA, we used a large collection of data from GPS, VLBI, SLR, and DORIS networks which span the Western U.S. Cordillera (WUSC) to precisely quantify present-day large-scale crustal deformations in a single uniform reference frame. Our work was roughly divided into an analysis of these space geodetic observations to infer the deformation field across and within the entire plate boundary zone, and an investigation of the implications of this deformation field regarding plate boundary dynamics. Following the determination of the first generation WUSC velocity solution, we placed high priority on the dissemination of the velocity estimates. With in-kind support from the Smithsonian Astrophysical Observatory, we constructed a web-site which allows anyone to access the data, and to determine their own velocity reference frame [see http://cfa-www.harvard.edu/spacegeodesy/WUSC/]. Our velocity solution was used in several recent investigations of the southwestern U.S. [Bennett et al., 1999; Shen-Tu et al., 1999; Flesch et al., 2000; Kreemer et al., 2000; Wernicke et al., 2000; Bennett et al., 2002; Friedrich et al., 2002; Niemi et al., 2002; Melbourne and Helmburger, 2002; Silver and Holt, 2002; Bennett et al., 2003]. This solution was also used as a "proof of concept" for the viability of PBO [see Fig. 2 of Silver et al., 1998].

In Bennett et al. [2002], we provided an updated analysis of velocity data for the WUSC region, including a joint analysis of GPS, VLBI, SLR, and DORIS data sets. We explored the sensitivity of the plate boundary deformation field to the analysis technique that we adopted to combine these data sets, and to the geodetic stations that were used to define a "North America plate" reference frame. We found good agreement among the various geodetic techniques, with velocity differences between techniques at the level of about 1 mm/yr. In Bennett et al. [2003], we again updated the WUSC velocity solution by adding several campaign GPS data sets that were previously not used. We used this updated velocity field to estimate the relative motions of the Colorado Plateau (CP), Sierra Nevada-Great Valley (SNGV) microplate, and the central Great Basin (CGB) using the new WUSC velocity solution. We found that SNGV-CP motion is 11.4+-0.3 mm/yr, N47W, whereas SNGV-North America (NA) motion is ~12.4 mm/yr, N47W, slower than previous geodetic estimates, and ~7 counterclockwise from Pacific (P)-NA motion. CGB-CP motion is 2.8+-0.2 mm/yr, N84+-5W, consistent with roughly east-west extension within the eastern Great Basin (EGB). Velocity estimates from the EGB reveal diffuse extension, with more rapid extension of 20+-1 nstr/yr concentrated in the eastern half which includes the Wasatch fault zone, as reported by Friedrich et al. [2002]. SNGV-CGB motion is 9.3+-0.2 mm/yr, N37+-2W, essentially parallel to P-NA motion. Our estimate is significantly slower than previous geodetic estimates for the western Great Basin (WGB), but generally consistent with paleoseismological inferences. The WGB region accommodates N37W directed right-lateral shear at rates of (1) 57+-9 nstr/yr across a zone of width ~125 km in the south (latitude ~36N), (2) 25+-5 nstr/yr in the central region (latitude ~38N), and (3) 36+-1 nstr/yr across a zone of width ~300 km in the north (latitude ~40N). We found that average extension in the direction of WGB shear is 8.6+-0.5 nstr/yr, comparable to average east-west extension of 10+-1 nstr/yr across the northern Basin and Range, but implying a different mechanism of extension. We also found that an alternative model for shear-parallel deformation, in which extension is accommodated across a narrow, more rapidly extending zone which coincides with the central Nevada seismic belt, fits the data slightly better.

BIFROST

We also continued research under the Fennoscandian GPS project BIFROST. Our recent work in the framewrk of this project focused on improving out knowledge of the space-time geometry of the glacial ice (the "ice history") from the Late Pleistocene onward.

In Schernick et al. [2002] we describe the design of the BIFROST GPS network, and the algorithms that we used to estimate 3D site velocity. We also provide a statistical assessment of the geodetic time series. In Johansson et al. [2002] we present an analysis of BIFROST GPS data representing the period from August 1993 to May 2000, including a comparinson of GPS determinations of 3D crustal deformtaion to predictions of a high-resolution degalciation model finding good agreement in both maximum uplift rate and the overall pattern of uplift. We also compared the GPS measurements with sea level rates from Baltic tide gauges. Finally, we performed detailed error analyses of BIFROST time series finding that spatial correlations in temporal position variations can be ascribed to snow accumulation on antennas and radomes.

In Wahr et al. [2002] we surveyed the role that geodetic observations are playing in the study of glacial isostatic adjustment (GIA). Observations of the Earth's gravity field, fluctuations in the Earth's rotation, and motion of the Earth's surface yield information on ongoing GIA. Satellite altimetric observations of ice sheet elevations are on the verge of revolutionizing our knowledge of mass imbalance of the polar ice sheets. We discussed some of the ways in which these measurement techniques have contributed to our knowledge of GIA and the present-day mass imbalance of the ice sheets and some improvements in measurement techniques that are expected to occur in the near future, and that should lead to notable improvements in our understanding of both GIA and polar ice mass imbalance.

There have been no reportable inventions or new technology under this grant.

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